DOCUMENT RESUME

ED 414 536 CG 028 196

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TITLE Computerized Adaptive Testing through the World Wide Web.
PUB DATE 1997-00-00
NOTE 31p.
PUB TYPE Reports - Research (143)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Adaptive Testing; Adolescents; *Computer Assisted Testing; High Schools; Higher Education; *Predictor Variables; *Student Placement; *World Wide Web
IDENTIFIERS Remote Scoring (Tests)

ABSTRACT

An important problem facing institutions of higher education is the number of students reporting that they are not adequately prepared for the difficulty of college-level courses. To meet this problem, a computerized adaptive testing package was developed that permitted remote placement testing of high school students via the World Wide Web. The rationale for developing the project, how the programming was formulated, implementation and security issues, and preliminary data on student performance/reactions to the testing are presented in this report. The sample for the study consisted of 223 high school students from a suburban school district. Seventy-two percent of the students were juniors--grade point averages ranged from 1.5 to 4.0 (on a four-point scale). Three placement tests (a holistically scored writing sample, a reading test, and a math placement exam) were adapted for administration over an Internet link. Results show that student performance and perceptions of the math and writing tests were generally positive. Plans are underway to use a computerized writing evaluation program to assess written essays and to project what a student's performance might be one or two years into the future. (RJM)

Computerized Adaptive Testing through the World Wide Web

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Abstract

A computerized adaptive testing package was developed that permitted remote placement testing of high school students via the World Wide Web. The project was designed to alert secondary students to the rigors of college work, and to let them explore their post-secondary schooling options. This paper describes the rationale for developing the project, how the programming was formulated, implementation and security issues, and presents some preliminary data on student performance/reactions to the testing.

Computerized Adaptive Testing through the World Wide Web

Introduction

An important problem facing institutions of higher education is to alert secondary students to the rigors of post-secondary work. New incoming students often report that they are not adequately prepared for the difficulty of college-level courses. Moreover, remediation rates at some post-secondary institutions can run as high as 90%, especially in states that lack a comprehensive community college system ("Study Finds," 1996; U.S. Department of Education, 1995). This lack of preparation can result in lower retention rates, higher levels of dissatisfaction, and uncompleted student goals. While high school counselors spend a good deal of their time preaching the benefits of taking challenging coursework, these voices of reason are not always heard.

There are a plethora of factors that can impact on student preparedness and success for college, but predominant factors emerge from the literature: family support and opportunities for feedback. The family support literature is best summarized in Christenson, Rounds, and Gorney (1992) who found a strong positive relationship between student achievement and parent involvement in education. Based on a synthesis of 153 research findings, five components of this factor were identified. Each of these is summarized briefly in the sections below.

Parent Expectations and Attributions. Though there is concern about the use of different methods to define and measure key concepts, studies evaluating parents' expectations, future aspirations, or current

expectations for children's academic performance, a general conclusion that can be drawn is that academic achievement is consistently correlated with high parent expectations and attributions. Some studies examined children's perceptions of parents' expectations and others measured expectations more directly by questioning parents. Whether parents' expectations and attributions initially affect children's achievement or vice versa is not known. Effort attributions (i.e., "you did well because you tried hard and practiced a lot") was strongly related to positive achievement outcomes. Realistic, high parent expectations for children's school performance are associated with positive academic performance regardless if the children's perceptions or actual parent expectations are investigated.

Structure for Learning. Most studies investigated elementary students within the structure of the home environment and how the environment can be manipulated to encourage and support academic learning. Those students assigned homework achieved higher grades than those not assigned such work. The beneficial effects are especially clear in middle and high school. Graded homework has a stronger impact than work unevaluated. Feedback and reinforcement produce higher student achievement. Parents can be helpful in the home process by providing (a) appropriate space to complete homework, (b) an established schedule, (c) adequate lighting and essential materials, (d) teacher support by providing rewards, checking homework, and stressing the value of school.

Home Affective Environment. Home affective environment is defined as the emotional environment in the home, and focuses on the relationship between parents and their children. Most studies concerned elementary

students. A positive affective relationship between parents and children increases the likelihood that the child will initiate and persist in challenging intellectual tasks and be socially competent. A positive parent-child relationship is related to academic success.

Discipline. Discipline refers to parenting methods used to control children's behavior. Most studies have investigated the effects of discipline on high school students, although some studies included preschoolers. One study found that shared responsibility (between parent and adolescent) for decisions was associated with higher grades. Students who make decisions on their own tended to have lower grades. In situations where parents controlled all decisions, no association with grades was found. Another study found that parent involvement had a consistent, positive effect on students' grades, but no meaningful effect on students' standardized achievement scores (Keith, 1991). In one study of high and underachieving high school boys, the high achievers described their parents as being less restrictive in comparison to the underachieving group. High achievers reported receiving more encouragement from their parents than the underachievers (Keith, 1991).

Parent Involvement. Parent involvement is broadly defined to include various activities that allow parents to participate in the educational process at home. The effect of parent involvement has been examined almost entirely at the elementary school level. Epstein (1987) suggests five types of involvement: (a) basic obligations of families to build positive home conditions that support learning, (b) school-home communications about school programs and children's progress (e.g.,

notices, report cards, conferences, phone calls), (c) involvement at school (e.g., attend school functions, volunteer work), (d) involvement in learning activities at home (e.g., monitor, discuss, and help with homework), and (e) involvement in decision-making (e.g., participation in PTA). Researchers who examined components of effective schools often found high levels of parent involvement. Achievement gains have been greatest when parents are involved at all levels of school life. In studies that specifically examined the effects of involvement increased parent involvement is positively correlated with increased student achievement.

Feedback opportunities manifest themselves in a variety of ways. One exemplary project was administered by the California Postsecondary Education Commission (California Postsecondary Education Commission, 1996). The purposes of the project were to: (a) improve student learning and academic performance in California public schools, (b) reduce the need for California public universities to offer remedial instruction, and (c) promote equality and merit in the college admissions process. Several programs were supported through this effort, but they all had six common characteristics:

- The purpose of the program was to increase the number of students who pursue higher educational opportunities from backgrounds and communities that have historically demonstrated low eligibility and college-going rates.
- The common strategy to accomplish this programmatic goal was the development of a cooperative relationship between public schools and higher educational institutions.

- While the programs were locally- or regionally-based, they were administered at the state level through a central office.
- The programs tended to serve students directly rather than concentrating on improving curriculum or instruction.
- The programs focused on providing services to students from groups who have documented low eligibility and college-going rates.
- The programs were centered on the transition between high school and college as contrasted to the flow within higher education.

One effort supported by the California project was the Advancement Via Individual Determination (AVID), a direct services program that involved 19,500 students. Strategies that the program used included: (a) preparation for college admissions and placement tests, (b) academic support in rigorous curriculum, (c) advisement and career preparation, (d) parent education, (e) instruction in writing and inquiry, and (f) tutors in academic courses. This was an impressive intervention in that 91 percent of the AVID graduates in 1995 completed a University preparatory curriculum in contrast to the statewide rate in 1994 which was only 32.2 percent.

One of the key components of a few California programs centered around the use of placement testing to prepare entering students for the rigors of college work. If a student takes a placement test in his/her junior year of high school, feedback can include a report on readiness for college coursework, and a revised high school curriculum if remediation is required. A barrier to administering placement tests of this kind has been the college/university's need to control security of

the test, yet make it available to those who would like to assess their skills.

Most colleges and universities have developed or adopted placement tests for the purpose of directing students into appropriate math, reading, or English courses (Chronicle of Higher Education, 1996). The rationale for placement testing is threefold. First, students who enroll in appropriate courses should have a more positive experience than those who enroll in courses that are either too difficult or too easy. They should be more satisfied with their college experience, and are therefore more likely to be retained. Second, because students are more likely to stay in classes that are appropriate to their ability level, departmental administrators can more carefully plan how to allocate faculty resources to class sections. Finally, the placement exams might serve as a basis for measuring the contributions of the University to the development of general education skills.

One of the problems with the implementation of most placement tests is that they serve as a summative assessment of what the student has acquired in high school or through work. There is generally no opportunity to "learn from the test" and alter study behavior or enrollment patterns.

A factor that can facilitate the delivery of tests or distance learning activities is the presence of the World Wide Web (WWW) (Shiffler, 1996). A web server can present hundreds of tests per hour with reasonable response time, and with some advanced planning, a modest amount of security (Shermis, 1997). Moreover, this medium has eclipsed others in terms of its popularity and accessibility (Campbell, 1997). WWW testing can be embedded within other educational activities or even

used as part of an "edutainment" package. Figure 1 shows a screen of a current popular "edutainment" package entitled, "You Don't Know Jack" (Berkeley Systems, Inc., 1997). The premise of the program is similar to those portrayed on popular television quiz shows--one is given a question (i.e., usually obscure) and a compressed amount of time to answer the question. What is impressive about this package is its use of audio and visual special effects to entertain the contestant during the testing process, even over slow modem lines. The package can even monitor performance to the point where it can award a contestant monetary prizes. The program, like its commercial television counterpart, is liberally sprinkled throughout with commercials.

Insert Figure 1 About Here

Development Work

The development of the testing package was conducted as part of a larger project involving an information kiosk created by a large midwestern university. The kiosk was sponsored by several enrollment management teams including representatives from the admissions office, financial aid, registrar, bursar, a freshmen/sophomore student division and the testing center. The purpose of the team was to encourage prepared high school graduates to enroll in a post-secondary experience. The testing package was designed specifically to allow students, beginning in tenth grade, to practice their skills using actual college placement tests. Feedback was to be designed so that the students could

create a trajectory of what kind of entry-level college courses in which they could expect to enroll (e.g., remedial versus college level courses).

An urban middle-class high school cooperated in the development of the kiosk software. Representatives from the high school included math and English teachers, counselors, and senior-level administrators. The first step was to obtain consensus on the functions that the kiosk would maintain and to discuss the accessibility of the software. For example, a number of high school representatives wanted the software to be available at a local library or from a student's home. It was decided that some functions (e.g., financial aid searches) could be accomplished from the home, but that other functions (e.g., testing) had to be performed on-site to allay considerations of security. Furthermore, minimum hardware/software configurations were specified. For example, the local library maintained only a text-based browser because they feared that some customers would use the internet to search for inappropriate material (e.g., pornography). However, the text-based browser did not support the graphics that are required for some graphic-based problems (e.g., geometry) in the test item bank.

Next, the teams from the University and high school went through a storyboarding process. Mock-up screens were generated by the development group for the kiosk information functions and presented to the teams. The teams essentially acted as a focus group for how they'd like to see the information presented. A number of problems were anticiapted in this way. For instance, the normal university web screens for the offices of the bursar, registrar, financial aid, and admissions were seen as too complex for an "outsider" to navigate.

Consequently simplified screens were created that had functionality of interest only to high school students. Later the reactions of the experts were confirmed with a small number of students.

Once the storyboards were completed, the coding was done in both Java and HTML. With regard to the programming for placement testing, a number of logistics were confronted. Test registration, for example, required the creation of several common gateway interfaces (cgi) to accommodate test security. At the first step, a counselor or teacher registers a student to take a test or a battery of tests. This process results in the issuance of a password that is good for two weeks. The student is given the password, but must take the test in a proctored area. Since the cgi checks for IP numbers, an attempt to take the test in an unproctored area will result in an error message to the student. We are currently working on an inexpensive means to remotely monitor test taking behavior to discourse cheating or other divergences from standard test-taking conditions.

Next, the web screens were pre-tested at the university to eliminate potential errors and "bugs". It was then piloted in a trial run at the high school. One problem encountered at the high school had to do with a relatively sophisticated "firewall" that they had recently installed. A "firewall" is a computer protocol that protects a network by isolating it from outside connections. The piloting process required programming modifications that adapted the system for this new configuration. Once the programming modifications were complete, the system was released for general use. One planned feature was not included in the first release of the web-based software. Originally we had desired that college counselors might be available to consult with

the high school students through a video and audio hookup. This feature, while important, was delayed until the second year of the project.

Method

Participants. The sample for the current study consisted of a total of 223 high school students from a suburban school district in a large midwestern city. The sample was comprised of 51% females and 49% males. No ethnicity information was collected, though the district is predominantly white. Twenty-six percent of the sample were high school seniors, seventy-two percent came from the junior class, and only two percent were sophomores. GPA ranged from 1.5 to 4.0 (on a 4-point scale), with a median GPA of 3.0.

Instruments. Three placement tests were adapted for administration over an internet link between the two institutions. The first test was a holistically scored writing sample based on a rotating set of prompts developed by faculty from the English department. These prompts are designed to focus students' discourse on a topic that would be in the realm of their normal experience. Students are given an hour to brainstorm, organize, and write an essay that is usually about 500 words in length. At least two instructors from the department evaluate the sample, and assign it a rating. The test was modified so that the high school students could type their responses into a web form document and submit it over the Internet directly to the department for evaluation. Feedback is provided in the form of an e-mail message to the student and counselor in about three days. Figure 2 illustrates the essay entry

screen. The completed information is submitted via the web browser to a database and then is evaluated on a web screen by evaluators from the Department of English.

Insert Figure 2 About Here

The second test was the Indiana-Purdue Reading Test, an objective reading assessment consisting of five parts--reading speed, comprehension, and three different types of vocabulary (Shermis, Wolting, & Lombard, 1996). The total reading score ranges from 0 to 153, and represents a weighted raw score composite. The correlation between the Nelson-Denny, Form E (Brown, Bennett, & Hanna, 1981) and the new test is modest, but significant [$r(348) = .37$, $p < .001$]. Internal consistency is fair, ranging from $\alpha = .58$ to $\alpha = .69$. The results of separate factor analyses for each subscale showed evidence of construct validity and acceptable unidimensionality. Students who score less than 80 are required to enroll in a developmental reading course. The test was modified for the Internet so that on the Internet it was administered through a common gateway interface (CGI) that called a web-compatible database. Feedback to the student and counselor is supplied immediately after the test is administered. Figure 3 provides an example of an item taken from this test.

Insert Figure 3 About Here

The last test was a computerized adaptive math placement exam (Hsu & Shermis, 1989). The testing mechanism utilized HyperCAT™, a computerized adaptive testing program that runs on either HyperCard (for Apple Macintosh) or WinPlus (for Windows/Windows 95) as a front-end processor. The testing algorithms were modified to run in a web environment. An adaptive test is one that conforms to the ability levels of the examinee. Computerized adaptive tests have several advantages over traditional paper-and-pencil tests. These include: shorter test administration times, better ability estimation, and perceptions by most examinees that the test is challenging, but not overwhelming. Moreover, the computerized format should result in better test security, ensuring that the tests are self-paced, and can be given at times convenient to the student. The adaptive testing package was accessed via the Web through a CGI and database that called the adaptive testing calculation routines. Feedback is provided as soon as the test is complete. Figure 4 highlights one item taken from the test.

Insert Figure 4 About Here

In addition to taking the exams, students are encouraged to browse the Web to obtain information about college admissions, financial aid, and registration. Figure 5 shows a sample of enrollment management options.

Insert Figure 5 About Here

Procedure. Students took the tests in a variety of formats. Almost all of the assessments were given as part of an overall classroom experience provided by their teacher in a laboratory setting during the regular school day. Once enrolled, students had to register themselves on the appropriate web page to collect background information. The greeting screen for this web page in included in Figure 6. The computer then directed the student to the appropriate test or battery of tests.

Insert Figure 6 About Here

These World Wide Web tests were implemented in an environment that posed only a few constraints. First, the tests had to be accessible from a PC or Macintosh computer running Netscape 3.01 or higher (with Java extension). The computer had to be equipped with both a sound card and an inexpensive digital camera. Second, the connection speed was to be ISDN or higher. Third, the computer connections were to have static IP addresses or a known range of addresses if allocated dynamically. And finally, the space in which tests were to be implemented would be monitored.

Student Survey. The placement testing exit survey was designed to solicit information about students' computing background, their perceptions of the testing experience, expertise and disposition of the

proctors, and some demographic characteristics. The information obtained from the survey is used internally to monitor proctor behavior, assess student satisfaction with the test experience, suggest areas for improvement, and specify possible technical innovations and recommendations that might improve the efficiency and effectiveness of the placement testing process. The survey also provides valuable information for external communication purposes with other service units/institutions by demonstrating how the placement testing process fits in with other university enrollment activities.

Results

Measures of Academic Performance. This section presents a brief summary of the descriptive statistics as indicators of academic performance of the high school students in mathematics and English. No information was available on reading performance.

The distribution of math test scores, based on an $N = 35$ is presented in Figure 7. The mathematics test scores ranged from 6 to 26, with a math mean score of 14.4 and a standard deviation of 4.72. These scores compared favorably to a college sample using the same test ($M = 11.68$; $SD = 5.66$) (Shermis, 1996).

Figure 8 shows the mathematics placement distribution. The respective course placements are based on the cutoff scores for one university, but may not apply directly to other locales. For puposes of interpretation, Math M010 and Math 001 would be considered remedial. Math 111 would the first college-level course, and the entry labelled "See Advisor" would be beyond the entry-level.

Similarly, Figure 9 presents the placement distribution for English, based on a sample of 188 students. The English placement test scores ranged from 2 to 21, with a mean of 12.04 and a standard deviation of 3.33. Courses labelled E010 and W001 are considered to be developmental. Courses labeled W131 or W140 are considered to be college-level courses.

Insert Figure 7-8 About Here

Student Satisfaction Survey. Satisfaction responses were obtained from 60 of the 223 students who participated in the testing program for an overall response rate of 26.9%. Overall, the results of the present survey suggest that students' disposition towards the computerized placement testing program was fairly positive. For instance, 26.7% (or 16 of the 60 students) had a favorable attitude toward the computerized testing process. In contrast, 25% (or 15 out of 60) of the respondents felt they could have done better if they had not taken the computerized placement tests. Approximatley 48% of the respondents gave a "neutral" response (on a five-point Likert scale) to the item: "I would have done better if I had not taken the tests on the computer". Note that a majority (55.7%) of the students said they had very little or somewhat limited experience with computers; whereas 44.3% (or 27 out of 61 students) reported having a great deal of computer experience.

With respect to efficacy of the test directions, a majority (75% or 45 out of 60) of the respondents found the current test directions to be clear and easy to follow. In contrast, only 11.7% of the respondents

felt the test directions were unclear and rather difficult to follow. Furthermore, 95.1% of the students reported that use of computers in test-taking was very easy or not too bad. Only 3 out of the 61 students (4.9%) found the computerized testing process to be confusing. The results with respect to test anxiety were rather mixed: 37.7% of the respondents felt the testing experience made them less anxious about getting into college; 21.3% felt more anxious; and 41% of the students were "undecided". However, a majority of the students (61.7%) said the testing experience made them to "realize the importance of the stress put on taking advanced courses to prepare for college".

With respect to computer knowledge of test proctor(s), a majority of the respondents (81.7%) had the perception that the proctor(s) had sufficient or extensive knowledge of computers. Fifteen percent of the respondents, however, found the proctor(s) to have inadequate computer knowledge. Perhaps this was due to some rather complex network problems that were encountered during the initial test sessions.

Student perception regarding the accuracy of the placement tests was assessed too, and the appropriate results are presented in Figure 10. For the present study, approximately 35% of the students (6 out of 17) who took the mathematics placement test found the exam to be an accurate measure of math skills; whereas about 65% (11 out of 17 respondents) felt that the math test was either too demanding or not a good measure of knowledge. With respect to the English placement test, approximately 62% (26 out of 42) of the respondents who took the exam felt it was an accurate measure of knowledge. On the contrary, a minority of the students (about 38%) found the English placement test to be too great of a demand or not a good measure of knowledge. Also, a

relatively small proportion of the respondents (31.1%) felt the English exam was a valuable learning experience.

Insert Figure 10 About Here

Discussion

This project illustrates a new, and perhaps innovative, way of applying internet technology to address the problem of under-prepared students who wish to pursue post-secondary education. One of the applications, computerized adaptive testing through the WWW, shows promise for allowing students to take the placement tests multiple times without compromising the test form. This project, and preliminary report, has shown the viability of using web-based technology for such an academic intervention.

While student performance and perceptions of the math and writing tests were generally positive, there are still a number of issues that have yet to be resolved. For example, while it is possible to make college placement recommendations based on a high school student's current level of performance, it is difficult to extrapolate that prediction one or two years into the future. That is, what exactly does one say to a high school sophomore who places into remedial college math? We wouldn't necessarily expect college-level performance, so what utility is there to provide feedback that confirms this? We are presently working to develop feedback that predicts where one is likely to stand in the future, given their current ability estimate and

curricular track. The IRT methodology used for the computerized adaptive tests should make the extrapolation process easier, though the predictions require empirical verification.

Our efforts to generate appropriate feedback will extend to the written essay test as well. For example, we are currently exploring the possibility of integrating the testing system with the Essay Grader, a computerized writing evaluation page developed by Dr. Ellis Page of Duke University (Page & Peterson, 1995). The Essay Grader, which has achieved remarkable indicators for reliability and validity (Page, Keith, & Lavoie, 1995), is normed on a secondary student population. If properly integrated with the web-based testing package, the Essay Grader could conceivably deliver normed and scored written essays within a matter of minutes.

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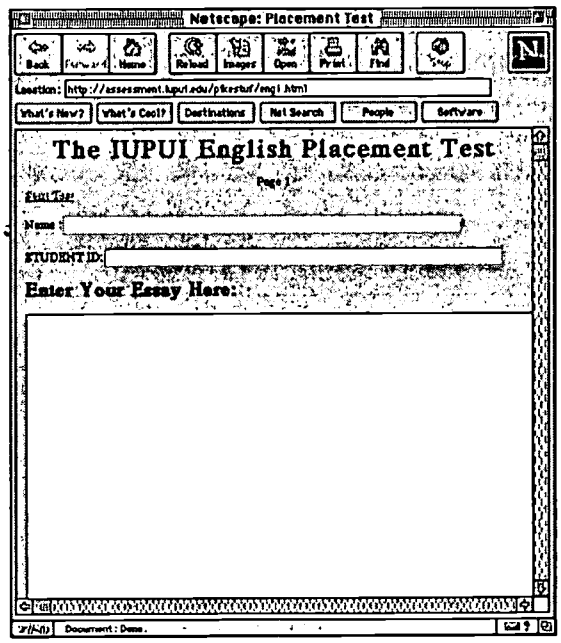

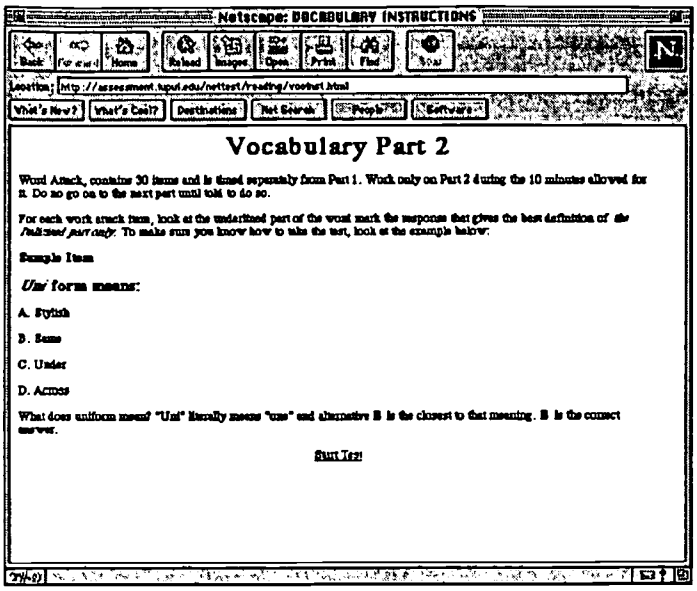

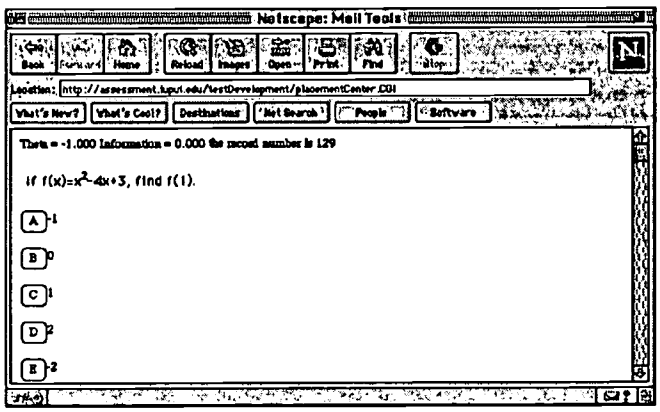

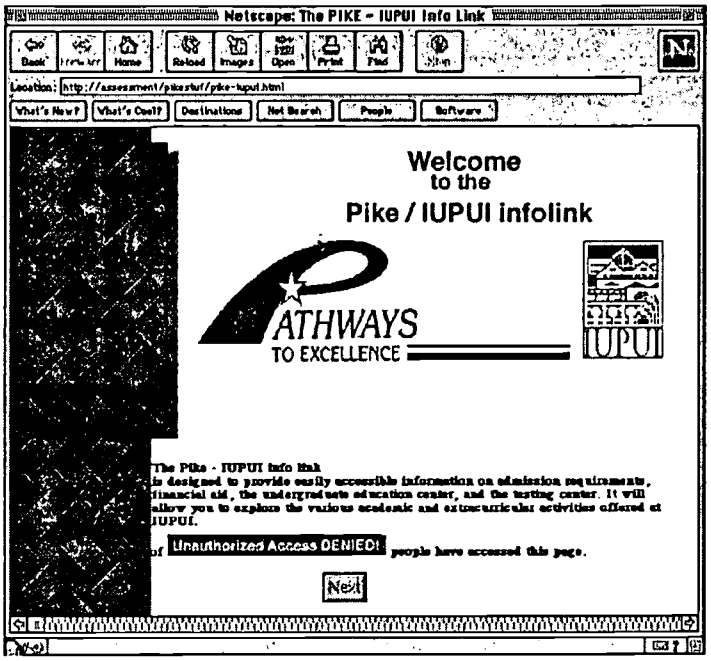

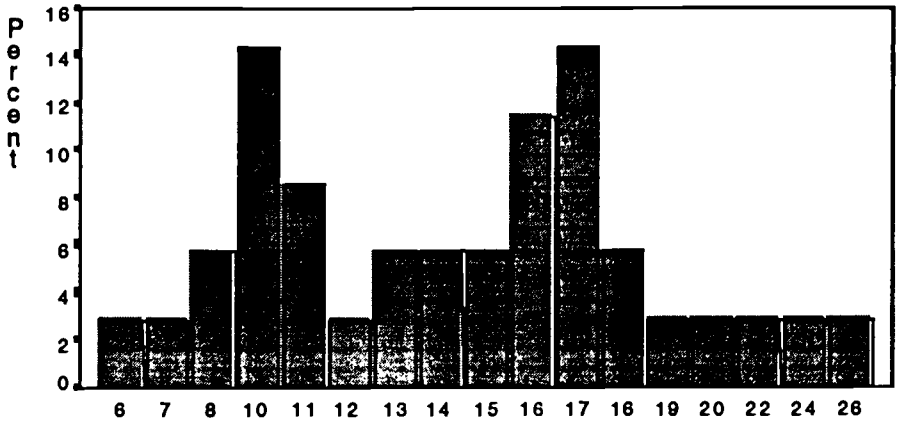
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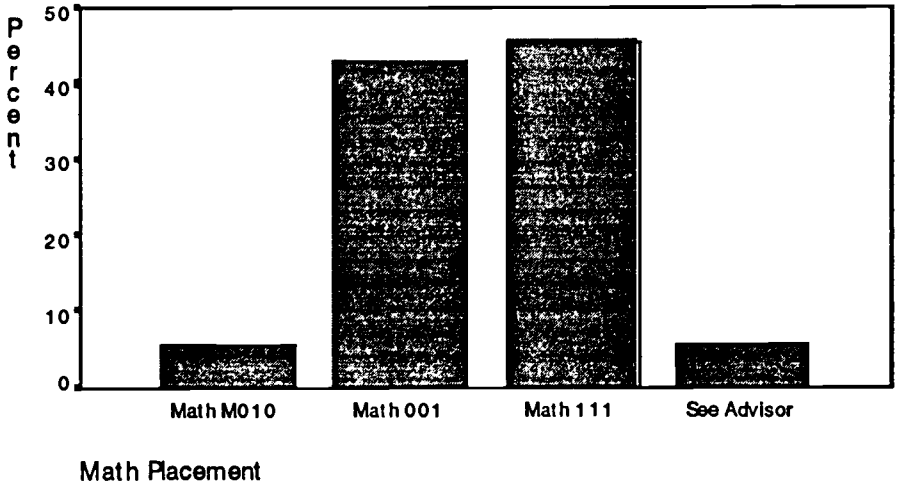
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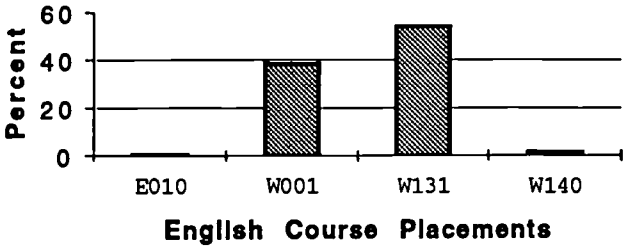

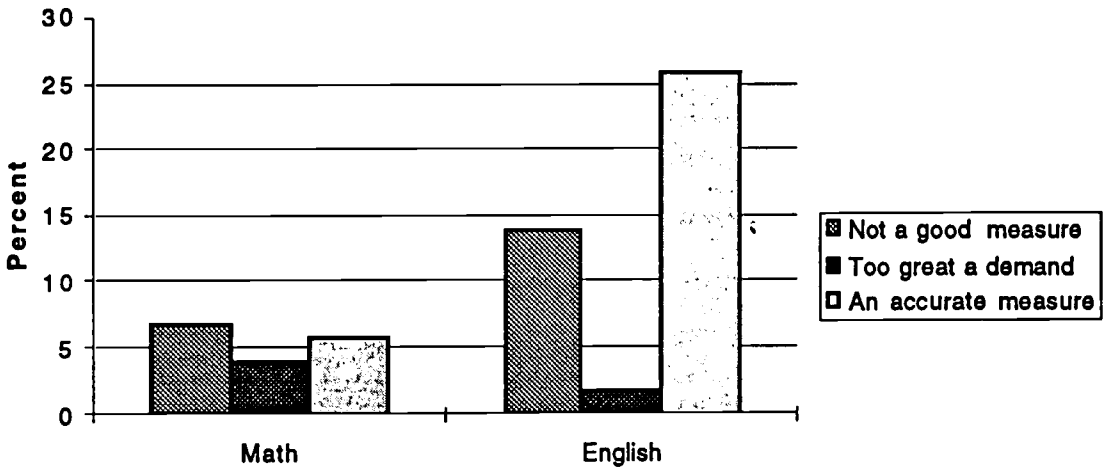

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Title:	Computerized Adaptive Testing through the World Wide Web
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Publication Date:	August 1997

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